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The Cuban Missile Crisis Revisited UMI 2005

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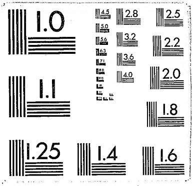

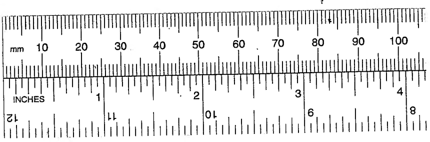

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Effectiveness Of Surface Sea Surveillance During The Cuban Crisis(U)

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OPERATIONS EVALUATION GROUP

STUDY NO. 685

EFFECTIVENESS OF SURFACE SEA SURVEILLANCE DURING THE CUBAN CRISIS (U)

By D. F. Mela and A. H. Dell
with L. Cohan

Approved by: W.G. Leight, Operations Evaluation Group
For The Director

30 April 1965

This study represents the view of the Operations Evaluation Group at the time of issue. It does not necessarily reflect the official opinion of the Chief of Naval Operations except to the extent indicated in the forwarding letter. It includes information of an operational rather than a technical nature, and should be made available only to those authorized to receive such information.

Enclosure (1) to
CNO ltr Ser 005P03
Dated 30 April 1965

Prepared by the
OPERATIONS EVALUATION GROUP
Center for Naval Analyses

DEPARTMENT OF THE NAVY
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1. Enclosure (1), prepared by the Operations Evaluation Group of the Center for Naval Analyses, is provided for information and retention. The study represents the best opinion of OEG at the time of issue.

2. This study evaluates the over-all effectiveness of the surface and air surveillance operations during the quarantine of Cuba in late 1962, and relates the surveillance effort to Soviet Bloc shipping identifications. The results of this analysis may aid in deriving future force requirements estimates, provide better inputs for future planning studies, and contribute to readiness for future large surveillance operations.

3. The Chief of Naval Operations approves this study for review and consideration by those commanders responsible for surface surveillance operations.

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42B	Fleet Air Wings (COMFAIRWINGSLANT only)
42D	Fleet Airborne Electronics Training Units (COFAETULANT-PAC only)
42J1	Readiness Attack & Attack Carrier Air Wings
42J3	Carrier Anti-Submarine Air Group
42N	Air Anti-Submarine Squadrons
42P	Patrol Squadrons
42X	Fleet Air Reconnaissance Squadrons

ABSTRACT

In late 1962 Navy ships and aircraft intensively patrolled large Atlantic and Caribbean areas to locate and track Soviet Bloc ships suspected of carrying intermediate range missiles and support equipment to Cuba. This study analyzes the effectiveness of these quarantine operations and the contributions of the several naval components. Because of the special circumstances of the Cuban crisis, the operations were carried on under conditions which greatly increased the force requirements. It is concluded the surveillance forces identified a very high fraction of traffic through the quarantine area.

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CONCLUSIONS

- The surveillance forces identified 80 to 90 percent of the ships steaming between European or Mediterranean waters and Caribbean or Gulf Ports.
- The political and military considerations of the operation increased force requirements by a factor of at least 6 over those required for surveillance only, thus compelling a relatively inefficient use of carrier aircraft and ships.
- Barriers from Puerto Rico and Bermuda could have been about twice as efficient if they had been designed for maximum effectiveness against west-bound traffic. The requirement to identify all shipping in the area forced the use of search plans less effective than crossover barriers specifically designed for use against inbound traffic only.
- The effective "identification width" of naval ships in the quarantine force was roughly 14 miles.
- P3A aircraft, in a major operation for the first time, were used to take advantage of their longer range to do a job that P2 and P5 aircraft could not do.
    - P2 aircraft identification coverage was 5900-8700 sq. mi. per hour.
    - P5 aircraft identification coverage was 2900-3700 sq. mi. per hour.
    - P3 aircraft identification coverage could not be determined from available data.
- Patrol aircraft in daylight made over half the identifications. ?
- Carrier aircraft were not efficiently used on surveillance missions.
- Search and track of special interest ships took 16 percent of the aircraft effort and 9 percent of the cruiser-destroyer effort. Had these units remained on general search, the number of ships identified would have been slightly, but not proportionately, increased.
- About 86 percent of merchantmen bound for Gulf-Caribbean ports from Europe, and 72 percent of those from North America were identified.
- Intelligence had an important effect on the character of the operation.
- The analysis produced useful planning factors and historical insights; however, better routine reporting and establishing a standby analysis team to study the results of future large operations would produce a large improvement.

RECOMMENDATIONS

- Standby analysis teams should be organized and become prepared to begin analysis at the start of future major operations.
- Required operational reports should be revised to ensure that data needed for analysis is reported routinely, preferably in a manner that facilitates machine analysis.

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I. INTRODUCTION

The Cuban crisis of October 1962 led to the largest naval operations since the Korean War. During this crisis the Navy supported at least 3 major activities: the quarantine and its surface surveillance; prosecution of many Soviet submarine contacts; and preparation and positioning of units to invade Cuba, if required. This study analyzes the surface surveillance operations as a result of the Chief of Naval Operations' desire to preserve and learn from the Cuban crisis operations (Cubex). Reference (a), analyzing the anti-submarine operations, and reference (b), dealing extensively with carrying out the contingency plans, cover other major aspects of these operations not considered here. Reference (c) is an OEG Study of Second Fleet communications during Cubex. References (d), (e), and (f) include the original OpNav requests for OEG work; reference (f), in particular, requested that OEG analyze and evaluate the force mix used in the Cuban Quarantine and assess the P3A aircraft contribution.

The general goals of this study were to evaluate the over-all effectiveness of the surveillance operations and to relate their results to the effort expended. Other purposes were to derive improved planning factors and reporting methods from the experiences of Cubex. This will contribute to force requirement estimates, provide better inputs for future planning studies, and contribute to readiness for future large surveillance operations.

The data for this analysis were transcribed from the records of ships and aircraft which operated principally in the area bounded by 12°N to 33°N and 52°W to 87°W. The data include aircraft sorties and ship positions from 21 October through 21 November 1962. However, due to time and manpower limitations, ship detections and identifications were recorded only from 21 October through 7 November. Over 5000 ships were identified during this period.

The decision to undertake this analysis and the data-collection required for it were unfortunately delayed, so that the records were not transcribed until March 1963. The sources and nature of the data and some of the resultant deficiencies are discussed in appendix A.

Considering the disposition and use of the ships and aircraft in this operation, it would seem that an appropriate measure of effectiveness would assign a much higher value to the location and reporting of Soviet Bloc ships than to others. On the other hand, orders were given to "locate, identify, report, and photograph all shipping in the Atlantic" by reference (g), which specified systematic search coverage. Time and discretion do not often permit the highest command level to inform forces participating in an operation of all the goals or considerations affecting its orders. Consequently, the lower levels may not have attached the same value to early location of specific ships at the expense of more "effective" and systematic over-all surveillance.

This report necessarily concentrates on certain aspects of surface surveillance which could be investigated with available data; it is not intended to be a complete analytical history of the crisis operations.

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II. DESCRIPTION AND CRITIQUE

This section describes the surveillance operation and concludes that the special circumstances of the Cuban crisis led to use of much larger forces than would have been necessary for surveillance without these constraints.

References (a) and (b) contain a detailed history of the Cuban crisis and a description of the quarantine plot in CinCLant Headquarters at Norfolk. However, a review of the more important aspects of the situation and brief chronology are given so that this report will be reasonably self-contained.

Chronology

The Cuban crisis resulted from Soviet introduction of medium range ballistic missiles (MRBM) into Cuba, and abnormally high Soviet submarine activity in the area, confirmed in mid-October 1962. The principal U.S. reactions were:

- Concentration of forces in the Florida Straits area for an invasion of Cuba, if required;
- Proclamation on 22 October of a "quarantine" using naval forces to prevent delivery of offensive weapons to Cuba;
- Extensive operations in prosecution of submarine contacts.

These measures, and the President's insistence that the Soviet missiles and IL-28 bombers be removed from Cuba, were successful. From 5 to 11 November, the missiles were removed and on 20 November the USSR announced that it would remove the IL-28's within 30 days.

The quarantine forces, although not engaged in a full blockade, induced Russian ships carrying arms to stop and return. This was apparently the result of the demonstrated U.S. ability to intercept them, and of our obvious intention and ability to use force if necessary.

The operation then evolved into an attempt to locate all ships which might be carrying prohibited materials to Cuba. For this, the surveillance forces tried to examine and identify every ship in the approaches to Cuba. Ships of special interest were to be tracked by designated aircraft or ships of the surveillance force.

Constraints on Quarantine Forces

As an operation to detect and, if necessary, stop ships carrying prohibited military materials to Cuba, the quarantine was effective. But the force requirements were increased and efficiency reduced by at least 3 major political-military constraints:

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- A requirement to intercept suspect ships 500 miles from Cuba (later reduced);

- The diversion of surveillance forces to search for and track designated special ships;

- The requirement for surveillance of all ships, not only those bound for Cuba.

Our ships were initially assigned to intercept and board Russian ships 500 miles from Cuba so as to remain beyond range of the Cuban air force. Since the intercepting ships acted on information from aircraft, aircraft searches were required still farther from Cuba. A line closer to Cuba would have provided very little time for the President and his advisors to act, and might have necessitated decisions by lower commanders which the higher authorities preferred to reserve to themselves.

The need to establish surveillance 500 miles and more from Cuba resulted in a line over 3 times as long as that from Florida to the Bahamas to Hispaniola, which is only 400 miles in length, and which would have sufficed for detection and identification only.

Force Dispositions and Missions

Air coverage was concentrated in 3 basic zones. The first ran north and south from Puerto Rico to Bermuda, and to the east and west of Bermuda. A second zone was from Puerto Rico to Jacksonville along the Bahamas and off the Florida and Georgia east coasts. Flights from Guantanamo toward the Bahamas also contributed to this coverage. The third area was just outside Cuban waters, covered from Key West and Guantanamo. In addition, flights from Lajes in the Azores covered selected mid-Atlantic areas.

Surveillance by ships was concentrated primarily in the barrier line initially stationed 500 miles from Cape Maysi, Cuba and later repositioned closer to Cuba, just to the east of the Bahamas as shown in figure 1. Ships also patrolled passages such as Florida Straits and Windward Passage. Because of the many merchant ships in the narrow passages, ships patrolling these passages identified more merchantmen than those on the quarantine lines.

In addition to a systematic coverage designed to locate and identify all shipping in the approaches to Cuba, many aircraft sorties were sent to search for specific ships which had been detected earlier or revealed by intelligence sources. Early in the operation, these special flights were given high priority. They altered the systematic search pattern and took forces away from prosecution of one submarine contact. These flights observed the activities of the Russian ships enroute to Cuba in an attempt to determine Soviet intentions at a critical period when the President was considering an invasion of Cuba. Navy ships were also assigned to intercept and follow ships of special interest. When 16 of the Soviet ships enroute to Cuba stopped and eventually reversed course, the effectiveness of the quarantine was demonstrated. The close coverage of Soviet ships which did not turn around gave

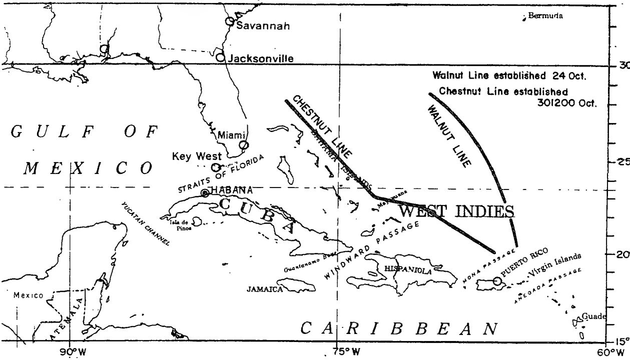

FIGURE 1

the USSR additional proof of the U.S. control of the situation, as well as satisfying the U.S. that prohibited war materials were not continuing to reach Cuba. After the USSR agreed to remove its missiles from Cuba, further special search and tracking missions were sent to verify and count the number of missiles removed.

These special search and tracking missions took 16 percent of the patrol aircraft surveillance effort, and 9 percent of destroyer and cruiser effort during the crisis. The effect of this diversion of forces from the systematic coverage can be estimated, as discussed in appendix A. If the ships and aircraft on special search and tracking missions had been used as the other surveillance units were, the number of merchantmen identified might have increased slightly, but not in proportion because coverage was already near saturation.

In addition, the requirement to identify all shipping in the surveillance area forced the use of search tracks which were less effective against inbound traffic than cross-over barriers, specifically designed to detect westbound traffic only, would have been. (This effect is discussed in appendix B.) The reasons for this requirement are not known, although it probably arose from the desire to keep track of all Bloc traffic to and from Cuba.

III. THE NAVAL EFFORT

This section presents statistics on the effort involved in the quarantine. The data include records from units which had no direct part in the operation and from some units which were assigned surveillance duties for only part of the period or as an incidental effort.

Efforts during the quarantine can be measured in terms of aircraft flight hours and ship-days in the quarantine area. A description of the effort must show the types of aircraft and ships present, to what missions they were assigned, how the effort was distributed geographically and what changes occurred in these distributions. The following provides this description.

General Surveillance Effort

Surveillance was primarily done by patrol aircraft (VP), with assistance from ships and carrier aircraft. Sixty-five percent of the VP effort was on ocean surveillance and special search and tracking flights; 34 percent was devoted to ASW, including 7 percent on escort of surface forces. Seventy percent of the VP surveillance flights were from 4 bases: Roosevelt Roads, Bermuda, Jacksonville, and Lajes. These flights could locate and identify inbound Bloc ships far enough from Cuba to permit surface intercepts to be made with sufficient decision time and beyond range of Cuban forces.

This was the first full-scale operation for the P3A aircraft, which were used to take advantage of their ability to operate at longer ranges than the other patrol aircraft, as discussed below.

The carrier aircraft spent nearly as many flying hours on surveillance as did patrol aircraft, but this effort occurred in limited sectors and intermittently.

Of the 1420 ship-days involved in the operation, 838 were spent at sea on surveillance, special search and tracking or ASW missions. Much of the ship effort was devoted to support or amphibious operations, rather than to search.

Aircraft Surveillance

Table I shows the distribution of patrol aircraft effort among the various missions and bases, and sortie times by aircraft types. Table II shows average sortie times by aircraft type, and average number of VP airborne by mission and time of day. The tables include Air Force flights

TABLE I
PATROL AIRCRAFT EFFORT BY MISSION, BASE AND TYPE
21 Oct-7 Nov 1962

A/C type/Base	Ocean Surveillance Sorties	Ocean Surveillance Hours	Special Ship Search & Track Sorties	Special Ship Search & Track Hours	ASW Search Sorties	ASW Search Hours	Task Group Escort Sorties	Task Group Escort Hours	Miscellaneous Sorties	Miscellaneous Hours	Totals Sorties	Totals Flt. Hours
P2												
Guantanamo	42	407.6	3	31.0	44	464.4					89	903.0
Roosevelt Roads	56	480.7	8	83.9	23	229.5					87	794.1
Jacksonville	43	387.1			20	211.2	38	432.9			101	1031.2
Norfolk	1	7.8							3	19.8	4	27.6
Lajes	28	282.2	6	60.9							34	343.1
Grand Turk					1	9.7					1	9.7
Argentia	2	16.2									2	16.2
Key West	26	202.9	1	7.0					2	10.6	29	220.5
Totals	198	1784.5	18	182.8	58	914.5	38	432.9	5	30.4	347	3345.4
[illegible]												
[illegible]	5	33.[illegible]	12	126.5	18	187.5			3	9.0	38	356.7
Lajes	4	34.5	2	20.1							6	54.6
[illegible] River	7	54.7	3	36.2	1	10.6			3	8.4	16	109.9
Totals	16	122.4	17	182.8	19	198.1			6	17.4	60	521.2
P3												
Bermuda	27	241.8	3	22.0	64	577.4					94	841.2
A3D-2P												
Guantanamo			1	2.5							1	2.5
[illegible] 50												
Bermuda	11	73.1	1	7.3							12	80.4
Lajes	2	22.9									2	22.9
Totals	13	96.0	1	7.3							14	103.3
GV-1												
Bermuda	12	76.9	1	7.2							13	84.1
TOTALS	268	2322.1	41	404.6	171	1690.3	38	432.9	11	47.8	529	4897.7

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TABLE II-A

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AVERAGE PATROL AIRCRAFT SORTIE LENGTH, HOURS
21 Oct-7 Nov 1962

A/C Type	Mission: Ocean Surveillance	Mission: Special Ship Search & Track.	Mission: ASW Search	Mission: Task Group Escort	Mission: All
P2	9.0	10.1	10.4	11.4	9.7
P3	9.0	10.5	10.4	--	10.1
P5	8.9	7.3	9.0	--	8.9
RB-50	7.4	--	--	--	7.4
GV-1	6.4	--	--	--	6.5

TABLE II-B

AVERAGE NUMBER OF PATROL AIRCRAFT AIRBORNE BY MISSION AND TIME OF DAY
21 Oct-7 Nov 1962

Time of Day (Zulu)	Mission: Ocean Surveillance	Mission: Special Search & Track.	Mission: ASW Search	Mission: Task Group Escort	Mission: Other
0000	2.00	1.17	3.56	1.11	0
0300	2.11	1.00	3.72	1.11	0
0600	1.89	0.94	3.94	0.94	0
0900	3.17	0.61	3.83	0.78	0.06
1200	7.72	0.89	4.33	0.83	0.17
1500	11.00	0.78	4.00	0.89	0.22
1800	9.61	1.00	3.83	1.11	0.39
2100	5.50	1.17	3.94	1.17	0.17
Average	5.38	0.95	3.89	0.99	0.13

An average of 11.34 patrol aircraft were airborne at all times.

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TABLE III

CARRIER AIRCRAFT EFFORT, INCLUDING LAND-BASED
21 Oct-7 Nov 1962

	Missions									
	Ocean Surveillance		Special Ship Search & Track.		ASW Search		Other*		Totals	
A/C/Ship or Base	Sorties	Hours	Sorties	Hours	Sorties	Hours	Sorties	Hours	Sorties	Flt. Hours
F8										
Independence							7	11.20	7	11.20
A4C										
Independence	1	1.78					2	3.17	3	4.95
A-1H										
Independence							2	4.57	2	4.57
RF8A										
Independence							2	3.20	2	3.20
E1										
Independence	57	270.97			2	8.45	2	7.73	61	287.15
Essex	27	116.30					74	339.63	101	455.93
Enterprise	73	295.32							73	295.32
Wasp	17	63.97							17	63.97
Randolph	42	180.00			14	59.05	21	74.03	77	313.08
Totals	216	926.55			16	67.50	97	421.40	329	1415.45
EA-1										
Independence	10	36.45	2	4.00	22	98.89	9	26.60	43	165.93
Wasp	35	133.78			4	16.00			39	149.78
Totals	45	170.23	2	4.00	26	114.89	9	26.60	82	315.72
S2										
Key West	47	215.73			2	2.00			49	217.73
Guantanamo	14	64.63							14	64.63
Essex	31	158.47			356	1863.78			387	2022.25
Wasp	68	276.47			102	389.75			170	666.22
Randolph	2	3.92			247	1116.77	34	56.88	283	1177.57
Totals	162	719.22			707	3372.30	34	56.88	903	4148.40
Helos										
Essex					33	59.25			33	59.25
Wasp	49	196.00			48	155.83			97	351.83
Randolph	3	3.62			143	254.83	77	94.45	223	352.90
Totals	52	199.62			224	469.92	77	94.45	353	763.98
F3										
Independence	1	1.50					8	13.47	9	14.97
Unspecified A/C										
Independence							670	1220.00	670	1220.00
Enterprise							995	2117.30	995	2117.30
Totals							1665	3337.30	1665	3337.30
TOTALS	477	2018.90	2	4.00	973	4024.60	1903	3972.21	3355	10,019.73

* Flights not directly associated with CUBEX

under Navy control. Data for 21 October to 7 November 1962 are shown because contacts have been recorded only for this period. Table III shows the distribution of carrier aircraft effort. Carrier aircraft flew over twice as many hours as patrol aircraft, but flew slightly less on ocean surveillance than did the VP.

The missions tabulated are "ocean surveillance," to locate and identify all merchant ships in the search area; "special ship search and track," flights to locate or track specific ships; "ASW search," including area search and prosecution of contacts; "task group escort," also primarily an ASW mission; and "miscellaneous," including ferry, transport, and other non-surveillance flights.

During the first 18 days, about 55 percent of the patrol flying hours were on ocean surveillance and special search and track, while 44 percent were on various ASW missions. However, during the following 2 weeks the ASW effort was considerably reduced. Surveillance took 80 percent of the patrol flying hours while 20 percent went to ASW. The average number of surveillance flying hours per day increased slightly during the last 14 days. P2 aircraft flew 72 percent of the patrol aircraft flying hours and accounted for over half the flying hours in each major mission.

Ship Surveillance

Table IV shows the distribution of ship effort by major missions. The many ship days devoted to transit are due to the operations of amphibious and logistic support ships. Figure 2 shows the distribution of destroyer and cruiser effort only, since these ships were the principal contributors. It is clear that the buildup for the quarantine was not complete until 24 October. Patrol aircraft sorties show a similar buildup. Hence, the evaluation of ship surveillance effectiveness excludes 21-23 October.

TABLE IV-A

DISTRIBUTION OF SHIP-DAYS AMONG MISSIONS
21 Oct-7 Nov 1962

Ship Type	Surface Surveillance	Special Search & Track	ASW Search & Track	Transit	Misc. Anchored or Docked	Total
Dest. Cruiser	312	34	450	172	152	1120
Carriers		6	29	9	39	83
Underway Replen.				91	169	260
Other Log. Supp.			5	89	87	181
All Others	14		2	255	357	628
Total	326	40	486	616	804	2272

TABLE IV-B

DISTRIBUTION OF SHIP-DAYSAMONG MISSIONS
21 Oct- 21 Nov 1962

Ship Type	Surface Surveillance	Special Search & Track	ASW Search & Track	Transit	Misc. Anchored or Docked	Total
Dest. Cruiser	562	48	799	338	303	2050
Carriers	14	10	42	9	70	145
Underway Replen.				178	341	519
Other Log. Supp.			5	145	165	315
All Others	22	1	6	388	676	1093
Total	598	59	852	1058	1555	4122

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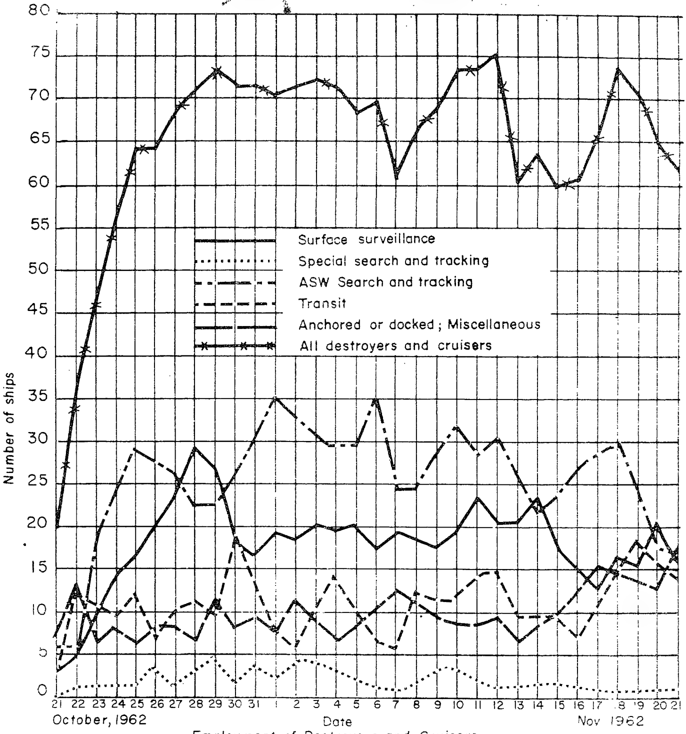

Employment of Destroyers and Cruisers

FIGURE 2

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IV. EFFECTIVENESS OF THE SURVEILLANCE EFFORT

This section describes the surveillance results. The first part describes and analyzes the contacts by source, location, time of day, and so on. The second part considers the over-all effectiveness of the operation. The measure of effectiveness here is completeness of coverage, measured by the fraction identified among all ships entering the surveillance area.

Principal conclusions of this section are:

- Patrol aircraft flying in daylight made over half of the identifications.
- Carrier aircraft return per flying hour on surveillance missions was low compared with patrol aircraft, indicating that they were not efficiently employed.

Merchant Ship Analysis

To accomplish the surveillance mission, all shipping in the areas of interest had to be examined. The information obtained on ships entering the surveillance area differed greatly. The most complete identification included name, type, origin, destination, etc., not all of which could be obtained from the ships or aircraft reporting. For this analysis, an identification was considered as "positive" when the name and type of the ship were obtained. Usually, the ship's registry was obtained with the name. In some cases failure to obtain registry resulted in ambiguity; for example, there are 6 "Santa Maria's" in Lloyd's Shipping Index Voyage Supplement of 16 November 1962. However, the name and position of a merchant ship, usually permits identification when combined with intelligence.

In many cases, less information on a ship may be sufficient for the type of identification desired. Merely knowing that a ship, such as a U.S. tanker, is not one of the special class in the Cuban trade might be satisfactory. Such identifications are defined as "negative identifications."

Table V shows levels of information obtained and numbers of contacts. The negative identifications account for approximately 11 percent of the total number of identifications reported. However, the 586 negative identifications do not represent 586 ships of the total number identified: some ships identified negatively were also positively identified and some ships may have been negatively identified more than once. In contrast, the positive identifications and naval vessels identified account for a total of 4,758 ships.

The table also shows the distribution of ships by reporting source, and indicates the predominant contribution of the land-based aircraft. Aircraft made nearly two-thirds of all the positive identifications; patrol aircraft (including Air Force) made slightly more than one-half of all the positive identifications. Landbased air, destroyers, and cruisers were the principal full-time surveillance forces, although much of their effort was also devoted to ASW. These components accounted for five-sixths of all positive identifications.

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TABLE V

DISTRIBUTION OF CONTACTS BY REPORTING SOURCE

Reporting Source	Number of Contacts			
	Positive Identification	Negative Identification	Naval Vessel	Total Identified
Navy patrol aircraft	1961	232	255	2448
Air Force aircraft	124	4	6	134
Landbased carrier aircraft	38	3,	2	43
Attack carrier A/C	77	36	77	194
ASW carrier A/C	361	54	110	525
All Aircraft	2561	329	450	3340
Destroyer types and cruisers	1204	150	153	1507
Underway replenishment	24	20	93	137
Amphibious and mobile Support Group	77	61	75	213
All other ships	91	26	30	147
All Ships	1396	257	351	2004
TOTAL	3957	586	801	5344

Figures 3 to 5 show the density of identifications made by ships, landbased air and carrier air. As would be expected, ships made the most identifications in restricted passages such as the Florida Straits and Windward Passage. There were also many contacts along the original "Walnut Line." The number of contacts depends on both the opportunities, as measured by shipping densities, and the search effort expended, measured by ship-days, flying hours, or length of barrier patrolled.

Table VI is a frequency distribution of positive identifications made per ship. Less than 10 percent of all the ships, or 13 ships, made 809 identifications, over half of the positive identifications; seven ships in the Florida Straits made 612 of these.

Figure 6 shows the distribution of identifications by hour for aircraft and ships, indicating that contacts by aircraft were mostly made in the daytime, while ships made identifications around the clock. The ships frequently identified by radio or signal request to the merchantmen they encountered, so that night was no obstacle. Aircraft flew surveillance missions almost entirely by daylight.

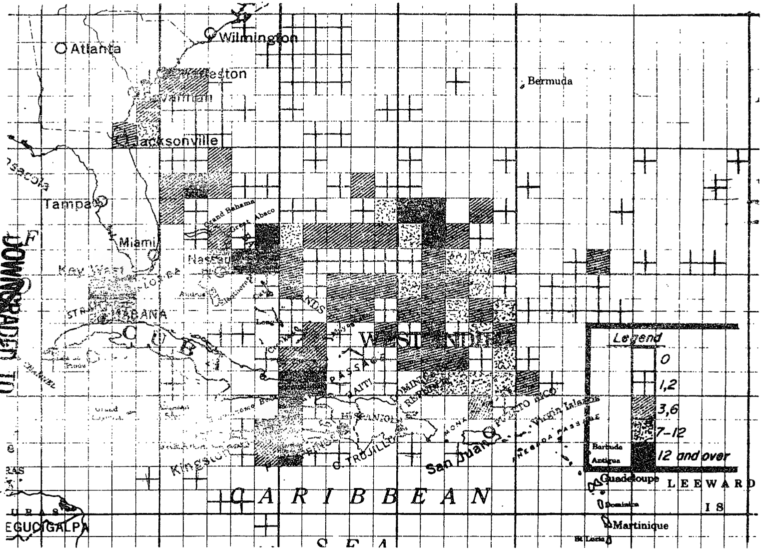

FIG. 3: CONTACTS BY SHIPS 21 OCTOBER - 7 NOVEMBER 1962

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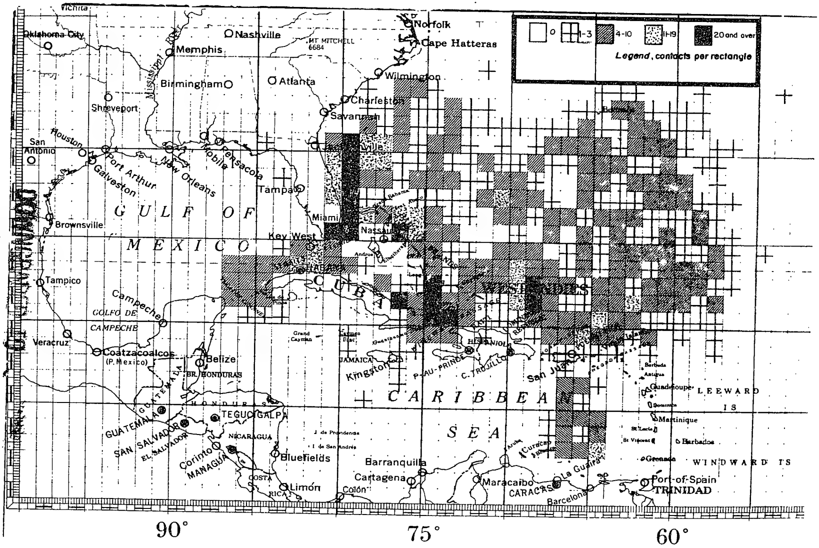

FIG. 4: ALL LANDBASED AIR CONTACTS 21 OCTOBER - 7 NOVEMBER 1962

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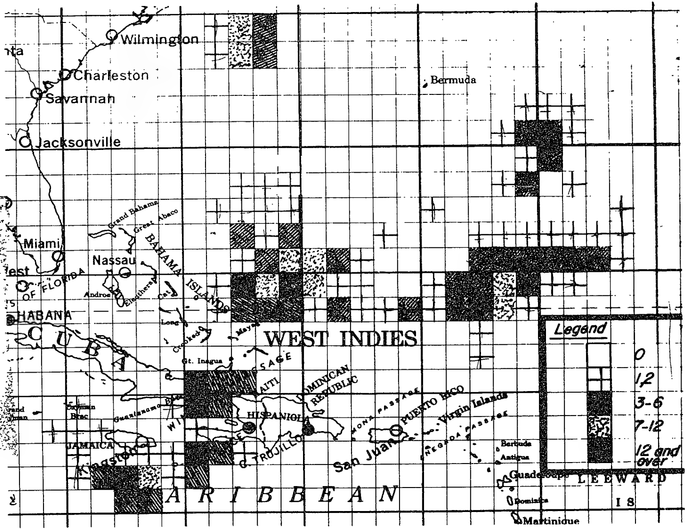

FIG. 5: CARRIER AIRCRAFT CONTACTS 21 OCTOBER - 7 NOVEMBER 1962

TABLE VI

FREQUENCY DISTRIBUTION OF NUMBER OF POSITIVE IDENTIFICATIONS MADE PER SHIP

21 October-7 November 1962

Number of Identifications Made	Number of Ships	Number of Identifications Made	Number of Ships
0	29	16	2
1	24	17	4
2	17	18	4
3	15	19	0
4	3	20	0
5	6	21	1
6	4	22	2
7	2	23	1
8	0	24	1
9	6	25	1
10	7	31	1
11	0	47	1
12	1	51	1
13	2	138	1
14	1	363	1
15	2		

Surveillance Effectiveness

This portion considers the surveillance effectiveness of carrier aircraft and ships only. Patrol aircraft, because of their greater contribution, are analyzed more extensively in part V, which follows.

Carrier Aircraft. From 21 October through 7 November 1962, 2 CVA and 3 CVS contributed to ocean surveillance. Carrier aircraft also flew surveillance missions from Guantanamo and Key West. The total carrier aircraft flight hours on surveillance was 2019, with a "return" of about 480 identifications; patrol aircraft made over 2000 identifications (about 4 times as many as carrier aircraft) while flying 2322 hours. The difference in identifications per hour is attributed to differences in employment, rather than significant differences in aircraft capabilities.

Identifications per flight hour is a misleading measure of the effectiveness of carrier aircraft due to over-coverage of the area near the carrier. It is therefore of interest to examine another measure for carrier air: identifications per opportunity.

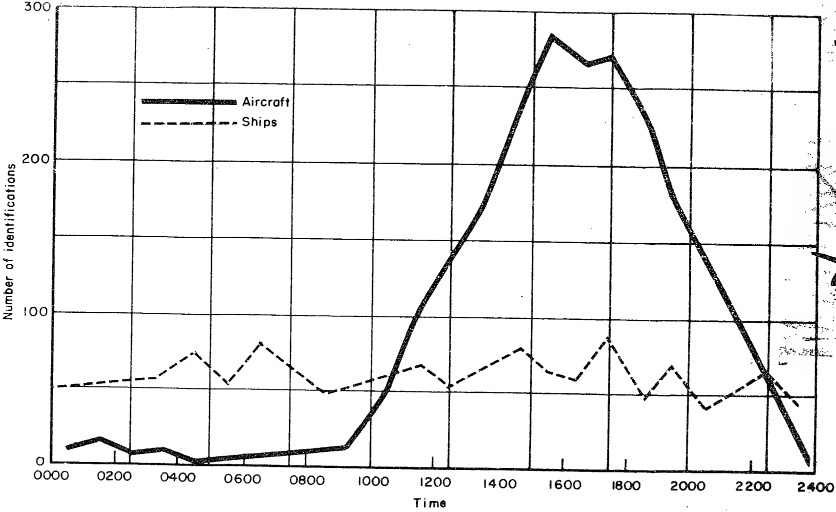

FIG. 6: DISTRIBUTION OF IDENTIFICATIONS BY TIME OF DAY
21 Oct - 7 Nov '62

The number of opportunities available to carrier aircraft was determined by counting the number of ships estimated to be within 150 miles of a carrier's noon position. Ship density was assumed to be evenly distributed within each of the 5x5 degree areas shown in figure 8, Estimated Number of Ships at Sea. The radius of 150 miles was chosen since it includes 98 percent of the 295 contacts which were reported with Tacan information. Of the reported contacts, 95 percent were within 100 miles of the carrier, and 90 percent within 90 miles. The 150-mile radius is assumed to also apply to a very high percentage of those contacts reported by latitude and longitude.

Table VII summarizes carrier air contacts per opportunity. The number of contacts represents the total (not including SUB or USN) reported by carrier-based aircraft on all types of missions, 21 October through 7 November.

TABLE VII
CARRIER AIR CONTACTS PER OPPORTUNITY

Aircraft Carrier	Number of Contacts	Number of Opportunities	Percent of Contacts per Opportunity
CVS-9	283*	156	182**
CVS-15	96	294	33
	379	450	84
CVA-62	77	255	30
CVA-65	28	280	10
	105	535	20
Total	484	985	49**

*Apparently,some ships completely identified on first contact were not well accounted for; then later re-identified only as Mers, Ship, or Tanker.

**These percentages are obviously too high, since CVS-9 reported more contacts than there were opportunities.

The search plans used by carrier aircraft are not known. However, if the sum of the Tacan and radar ranges is the maximum detection range from the carrier, an aircraft at an altitude of 4,500 feet can cover 150 miles when flying about 75 miles from the carrier. He can receive Tacan and radar targets simultaneously; plot the range and bearing of the target from the carrier; fly out and identify the target and then return to voice communications range to make or relay his report.

The short average ranges from the carriers at which detections were made by carrier aircraft, table VIII, indicate a strong likelihood of overcoverage. It might therefore have been more efficient to use the carriers for surveillance and ASW in areas where shipping was more concentrated, rather than in the open ocean areas between the Bahamas and Bermuda, other missions permitting.

TABLE VIII

REPORTED SHIP RANGES FROM CARRIERS

	Type A/C	No. Ships	Av. Range, mi.	Max. Range, mi.
CVS	WF2	62	63	216
	S2F	154	41	170
	Helo	6	36	56
	All	222	47	216
CVA	F8U	6	43	90
	A4D	3	88	94
	AD-5,6	28	50	102
	WF2	18	33	70
	F3H	5	60	100
	All	60	46	102
Total		282	47	216

Ships (Excluding Carriers)

Most ships in the force were not stationed where they could locate and identify a maximum number of merchantmen; they were stationed on the barrier to intercept and trail suspect ships and stop them if so ordered. It was expected that Bloc ships inbound toward Cuba would be detected first by aircraft, and this is what occurred in most instances.

One measure of ship surveillance efficiency is the fraction of ships passing through the quarantine line which were identified. Of a sample of 90 ships on westbound courses from Europe and the Mediterranean to Caribbean ports (described below) 26, or 29 percent, were identified by ships of the quarantine line. Thirteen of these were identified before October 30 on the Walnut Line, and 13 after October 30, when the shorter Chestnut Line was manned. The initial ship spacing in the Walnut Line was 46 miles. This implies an effective "identification width" of 46 x .29 = 14 miles for the ships on this line. However, this figure should be used with caution.

Another measure of ship effectiveness, though less meaningful than the fraction of all ships identified, is the number identified per ship-day. The ships made a substantial contribution, identifying 400 merchantmen between the Walnut Line and the line Bahamas-Hispaniola-Puerto Rico from 21 October through 7 November 1962. The 177 ship-days yielded slightly over 2 identifications per ship-day in this area. However, the varying merchant ship densities, the presence of ship lanes, information passed by aircraft, the use of ships for trailing and interception, all affected the efficiency of the ship search. Also, some data were transcribed inconsistently, affecting the accuracy of the estimates of identifications per day. As pointed out earlier, a few ships made most of the identifications because they were in areas of high shipping density. Figure 7 shows the distribution of contacts identified by percentage of the searching force, indicating that returns per searcher were far from homogeneous. Finally, many identifications were made without approaching close enough to read the ship's name. The fractions identified by signaling or by radio and visually by close approach are not known.

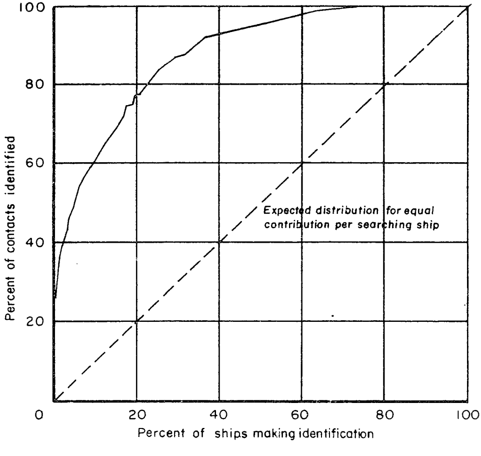

FIG. 7: PERCENT OF IDENTIFICATIONS VS. PERCENT AND NUMBER OF SHIPS MAKING IDENTIFICATIONS

V. PATROL AIRCRAFT OPERATIONS

In this section several aspects of patrol aircraft operations are analyzed. Ocean surveillance is an assigned mission for patrol aircraft, and many of the crews are accustomed to keeping detailed records. Patrol aircraft performed a major role in sea surveillance, and the data from them were the most amenable to detailed analysis. Separate portions of this section deal with search and identification rates, ordnance expenditures and failures, the use of the P3A, and aircraft utilization. Principal results are:

- The P2 area coverage rate for ship identification was 5900-8700 square miles per hour; P5 rate was 2900-3700 square miles per hour. The P3 rate cannot be determined from the data available.
- The P2 and P3 operational utilization rate was about 100 hours per month; the P5 rate was 70 hours per month.
- The P3 aircraft were used to exploit their superior range.

Patrol Aircraft Search and Identification Coverage Rate

Patrol aircraft flew hundreds of missions along planned tracks. When they detected ships, they flew toward them to identify them visually, after which they resumed their surveillance tracks. For some planning purposes, it is useful to know how many square miles per hour an aircraft could cover in this mission. The data received were sufficient to make estimates of the surveillance rate for P2 and P5 aircraft, but not for the P3.

To estimate the area coverage rate, two quantities are needed: identification sweep width (called identification width hereafter) and speed of advance along the track. The product of these is the surveillance rate.

Here the term "identification width" refers to the sweep width for identification, not for detection. More precisely, the identification width, W, is defined by

$$W = \int_{-\infty}^{\infty} P(x)dx$$

where W = identification width, miles
x = distance from search track, miles
P(x) = probability that a ship at distance x from the track will be identified.

The data include numbers and locations of identifications on each track flown, as well as the planned tracks. In addition, the shipping density in various areas has been estimated by ONI; figure 8 is a tabulation for October 1962. With such information, the value of an identification sweep width may be estimated.

The ONI survey shows numbers of ships within regions bounded by parallels and meridians in multiples of 5 degrees. The estimated number of ships per region varies from one region to another, and the areas of regions differ with latitude. In each $5^\circ \times 5^\circ$ region an estimate can be made of an identification sweep width; the estimate W_i for the i^{th} region uses the following quantities:

S_i = estimated average number of ships in the i^{th} region

A_i = area of the i^{th} region

$s_i = S_i/A_i$ = average shipping density in the i^{th} region

L_i = number of track miles on surveillance flights in the i^{th} region

C_i = number of contacts identified in the i^{th} region

$W_i = C_i/L_i s_i$ = estimated identification width in the i^{th} region.

Based on assumption of uniformly random distribution of ships and negligible self overlap of aircraft track, appendix C shows that

$$W_i = \frac{C_i}{L_i s_i} \tag{1}$$

provides an estimate of identification width for the i^{th} region, where W_i has an expected value of W and variance $\frac{W}{L_i s_i}$.

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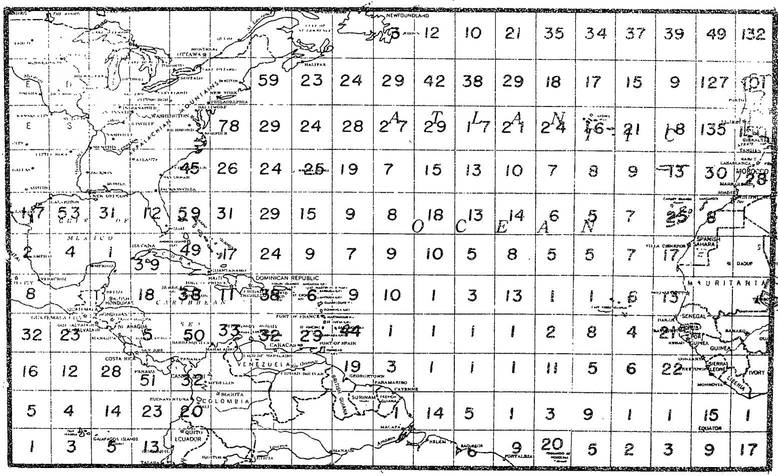

FIG. 8: ESTIMATED NUMBERS OF SHIPS AT SEA, OCTOBER 1962

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The values of W_i from separate regions can be combined to provide an over-all estimate of W. Appendix C shows that the over-all estimate

$$W^* = \frac{\sum_{i=i}^{n} C_i}{\sum_{i=i}^{n} L_i S_i} \qquad (2)$$

is a weighted average of n individual values of W_i, with an expected value of W and the smallest sampling variance of all linearly weighted averages of the W_i.

The assumptions in deriving equations (1) and (2) are not valid in the western and southern parts of the surveillance area because narrow passages imposed densities with very sharp variations within a 5° x 5° area. Patrol tracks, particularly from Guantanamo and Key West, were at times so close to land that the ocean area surveyed was reduced. If a patrol track includes or excludes a dense traffic, estimates of identification sweep width can be much larger or smaller than expected for a uniform density in a region. Some of the Guantanamo and Key West flights also included considerable overlap. Figure 9 shows numbers of identifications by land based aircraft in one-degree cells, and the lack of uniformity among the islands and straits.

The assumptions of uniform-random distribution of shipping and non-overlapping flight tracks, with no surveillance of land, appear most valid north of Puerto Rico to Bermuda. According to reference (h), a sample comparison between ships' positions and those estimated by dead-reckoning ships along shipping lanes showed a mean deviation of 88 miles from the lanes. Ships with many origins and destinations transit this area, so they tend to be more uniformly distributed in it. Table IX summarizes data for flights from Bermuda and Roosevelt Roads which covered most of the area between Puerto Rico and Burmuda.

Of the 78 flights represented in table IX, 74 took off between 0400 and 1200 local time. Only 1 of the remaining 4 flights was largely in darkness. Thus, these sweep widths are for daylight surveillance. The estimates are for positive identification by name; negative identifications would increase the values shown by less than 10 percent.

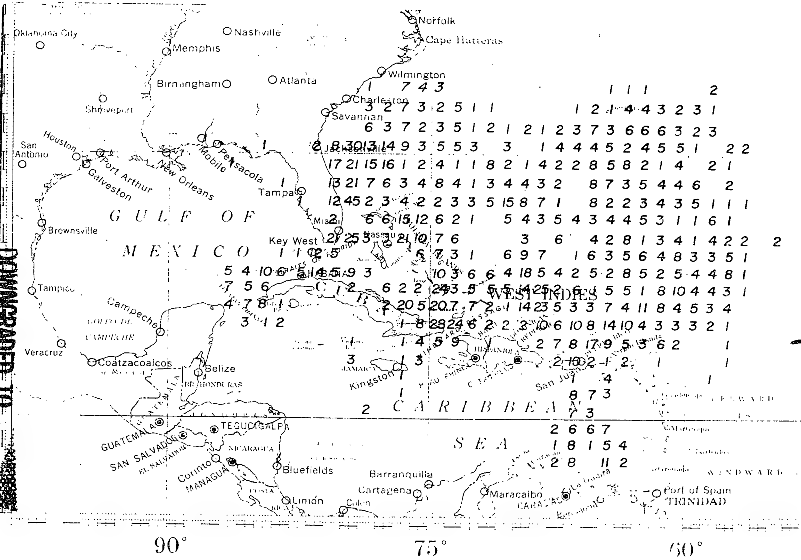

FIG. 9: PATROL AIRCRAFT CONTACT DISTRIBUTION IN ONE DEGREE SQUARES
21 OCTOBER - 7 NOVEMBER

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TABLE IX

IDENTIFICATION WIDTHS FOR PATROL FLIGHTS FROM BERMUDA AND ROOSEVELT ROADS

Location	Number Flights	Type A/C	Total Track Miles	Contacts Positively Identified	Identification Sweep Width Miles
Bermuda	22	P5	23,326	156	24
Bermuda	18	7 C-130 10 RB-50 1 P3	15,260	75	20
All Bermuda	40	Various	38,586	231	22
Roosevelt Roads	38	P2	50,425	434	44
All Bermuda and Roosevelt Roads	78	Various	71,552	665	40
All Bermuda and Roosevelt Roads Minus Adjacent Areas	78	Various	59,975	525	48

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Aircraft were usually instructed to divert up to 45 miles from their tracks to investigate contacts. With perfect coverage, an identification width of 90 miles would be expected; achieved identification widths were about 1/2 of this. Although it is not possible to explain or isolate every reason why actual performance falls short of the theoretical, several contributing factors may be considered.

First, the tracks do overlap themselves, which is unavoidable when the tracks all emanate from two points. The greatest overlaps occur near Burmuda and Roosevelt Roads, where the aircraft also have land in sight. Consequently, estimates of identification width were made after deleting regions closest to the bases. About one-third of the tracks in the sample were in the 2 deleted areas adjacent to the bases. For those (deleted) tracks the combined identification width was 15 miles, whereas the combined identification width in the remaining areas was 48 miles. On the basis of track lengths and shipping density, the deleted adjacent areas should have accounted for 45 percent of the identifications, but actually provided only 21 percent. Hence overlap alone does not fully explain the dicrepancy.

Another possible reason for the number of contacts near base to be lower than expected is that an aircraft near its endurance limit must return to base without investigating all contacts on the remainder of its route. This effect evidently did exist in this operation, as is shown by table X.

Weather also occasionally degraded search. A low ceiling may force aircraft to fly lower, reducing the line of sight and sweep width. In general the weather was good during this period, but at least one flight flew at 800 feet to stay under a low ceiling.

The speed of advance of patrol aircraft on surveillance depends mainly upon the aircraft's cruising speed and the number of contacts it must investigate. To estimate the speed made good along surveillance tracks, the total mileages of the individual tracks were measured. Flight time on each track and the number of contacts were recorded. Then the average contacts per hundred miles of track and the average speed of advance along each track were computed.

Figure 10 shows the relationship of speed of advance along the track and the contact density per 1000 miles of track, with lines of best fit by the least square method. The P2 SOA is reduced 1.36 knots for each additional contact per 1000 miles of track, which implies about 5 minutes "lost" per additional contact. The corresponding figure for the P5 is somewhat larger, being 7 minutes. For all P5 flights the average contact density was 8.6 per 1000 miles, and the average speed of advance was 122 knots, or 87 percent of the nominal P5 cruising speed of 140 knots. For the P2, average contact density

TABLE X

DISTRIBUTION OF CONTACTS BY PORTION OF FLIGHT

Patrol Aircraft Based at Bermuda and Roosevelt Roads

Flights	No. of Detections			
	First One Third of Flight	Middle Third of Flight	Final One Third of Flight	No. of Flights
Combined Bermuda	95	116	60	40
Roosevelt Roads	160	178	143	38
Bermuda plus Roos. Rds.	255	294	203	78

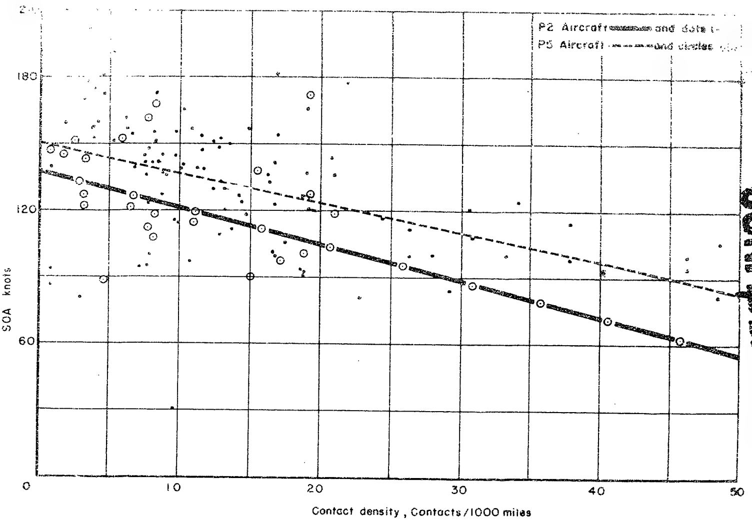


FIG. 10: RELATIONSHIP BETWEEN AIRCRAFT SPEED OF ADVANCE ALONG TRACK AND CONTACT DENSITY

was 11.7 per 1000 miles and the average speed of advance was 134 knots, 79 percent of the nominal cruise speed of 170 knots.

Ship density per 100 miles of track length can be converted to an estimate of density per square mile by computing the maximum range of detections. In this case, aircraft were to divert up to 45 miles on either side of their tracks, or 5-10 miles less than the line of sight, from a normal altitude of 1500 feet, against ships. Roughly, the contact density per 100 miles of track length equals the contact density per 10,000 square miles.

From identification width, in this case 78 percent of the contact width, and speed of advance, the surveillance area coverage rate can be calculated. The speed of advance used must reflect anticipated contact density to be most useful for advance planning.

Here, the P2 aircraft had an average speed of advance of 134 knots and identification sweep width of 44-65 miles, or a surveillance coverage rate of 5900-8700 square miles per hour. The P5 had a corresponding coverage rate of 2900-3700 square miles per hour.

Patrol Aircraft Utilization

Patrol aircraft utilization during Cubex was well above normal peace-time rates of 50-60 hours per month, and occasionally above the planned wartime rate of 120 hours per month, particularly early in the operation. Data collected for OEG by ComASWForLant provided a statistical description of the flying hours by date and aircraft type. Later, the distribution of aircraft under ASWForLant control, by date, was carefully compiled and reported in reference (a). This permits calculation of aircraft utilization by type, as in table XI.

These figures provide a guide to the patrol aircraft usage that might be achieved in future operations of this type with present men and logistic support. However, they must be used with caution and judgment in another situation. In particular, ship surveillance did not require that ASW gear be "up." Thus, it cannot be assumed that patrol aircraft could fly at the same rate if assigned to ASW.

Role of the P3A

The P3A played a special role during Cubex. Of 119 P3A flights, 61, or 51 percent, were devoted to finding and tracking designated ships; only 7 percent of the P2 and P5 sorties were on these missions. P3A aircraft flew 42 percent of the special search and track flying hours.

TABLE XI

PATROL AIRCRAFT UTILIZATION

	21 Oct - 7 Nov	21 Oct - 21 Nov
P2 Av. No. A/C	55.8	57.2
Flt. Hrs./Day	3.3	2.9
P3 Av. No. A/C*	8.9	9.4
Flt. Hrs./Day	3.3	2.8
P5 Av. No. A/C	20	20
Flt. Hrs./Day	2.3	1.8

* VP-8 only, other P3A participation was too limited to include.

P3A aircraft were sent on missions where their greater range was essential. On special ship search and track missions, the P3A's averaged 5.5 hours in transit to and from station, and 5.2 hours on station. For a 300-knot nominal cruise speed, this implies operations at over 800 miles from base. At this radius the P2 would be able to stay on station for only an hour or two and the P5 capability disappears. This is undoubtedly a major reason why so much P3A effort was spent on special search and track missions.

Table II-A is misleading with respect to P3A sortie lengths. It shows a very short average sortie time for surveillance because of many short transit flights during which the aircraft also rigged ships. The P3A special search and track and ASW flights were slightly longer, on the average, than those of other aircraft. However, because of the P3A's higher speed to and from station, their total tracks were longer.

Sonobuoy and Ordnance Expenditures

The Cuban Quarantine provided an excellent data source for planning factors on the ordnance expended by VP aircraft in realistic ASW and surveillance operations. These data can assist in estimating logistic requirements for similar operations, determining ordnance reliability, and examining aircraft loading requirements.

During the month of the quarantine, there were 835 VP sorties. Of these 304 reported at least one piece of ordnance expended. It is assumed here that if an aircraft reported at least one expenditure, it reported all of them. The 531 sorties which did not report expenditures may or may not have expended ordnance. A detailed breakdown of the sorties is given in table XII. Sorties having what was thought at the time to be a submarine contact are listed separately.

Total expenditures by type are shown in table XIII with the reported reliability and average expenditures per sortie. Sonobuoy expenditures are shown by mission type in figure 11.

Because of the great variability of ordnance expenditures per sortie, as evidenced in figure 11 for both ASW missions and non-ASW missions, no valid planning factors for ordnance can be derived.

TABLE XII

NUMBER OF VP SORTIES

	Reporting Expenditures		Non-Reporting	
ASW Missions				
Possible Sub Contact	101		6	
No Sub Contact	82		25	
Total		183		31
Surveillance Missions				
Possible Sub Contact	11		9	
No Sub Contact	110		491	
Total		121		500
Total		304		531

TABLE XIII

TOTAL ORDANANCE EXPENDITURES

Ordnance	Expended	Failed	Aver. on ASW missions	Aver. on other missions	Reliability(%)*
Sonobuoys**	2901	184	13.3	3.8	93.66
PDC	1889	23	8.2	3.2	98.78
Marker	634	1	2.2	1.9	99.84

* Because failures are often not recorded, the reliability figures must be considered an upper limit on the actual reliability.

** Of these, nearly 75 percent were SSQ-28, which had a reliability equal to the average.

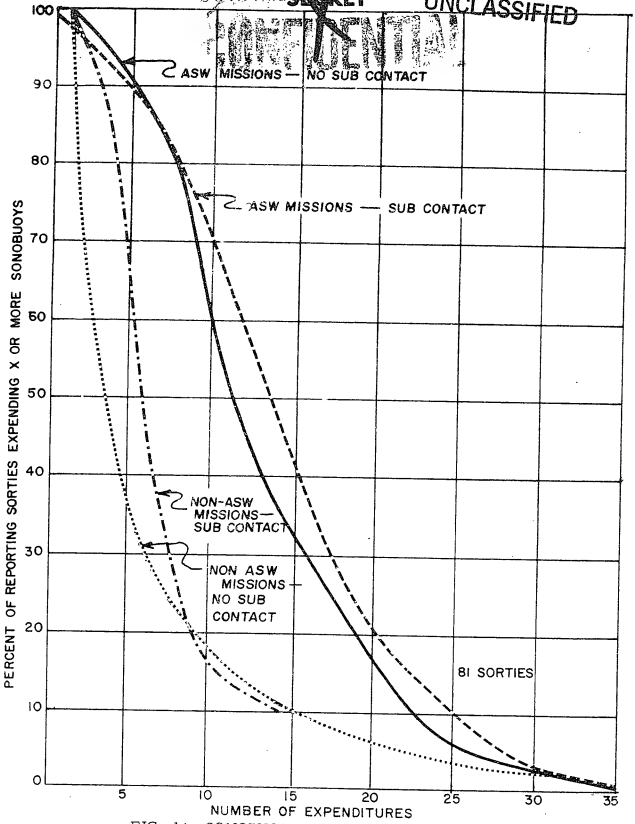


FIG. 11: SONOBUOY EXPENDITURES

VI. OVER-ALL EFFECTIVENESS

Previous sections of this report dealt with the effort expended in the quarantine and associated surveillance operations and with the resulting contacts and identifications. Some important aspects of the over-all effectiveness of the operations are treated here.

Major conclusions of this section are:

- Based on Lloyd's Voyage Supplement about 86 percent of the merchant ships on trips between Europe and the Gulf of Mexico-Caribbean area were identified by surveillance forces, and about 72 percent of the ships steaming from the east coast of North America toward the Gulf-Caribbean area were identified;

- Carrier air identified a substantial percentage of merchant ships passing through the area, but the carriers were stationed so that their surveillance efforts essentially duplicated the patrol aircraft and ships' effort.

The area involved covered about 3 million square miles from 12°N to 35°N and between 52°W and 87°W. Ships transited the area in various directions: some went through a corner of it and were exposed to surveillance for only a day or two while others were exposed for over a week. Therefore, groups of ships which had about the same exposure must be studied.

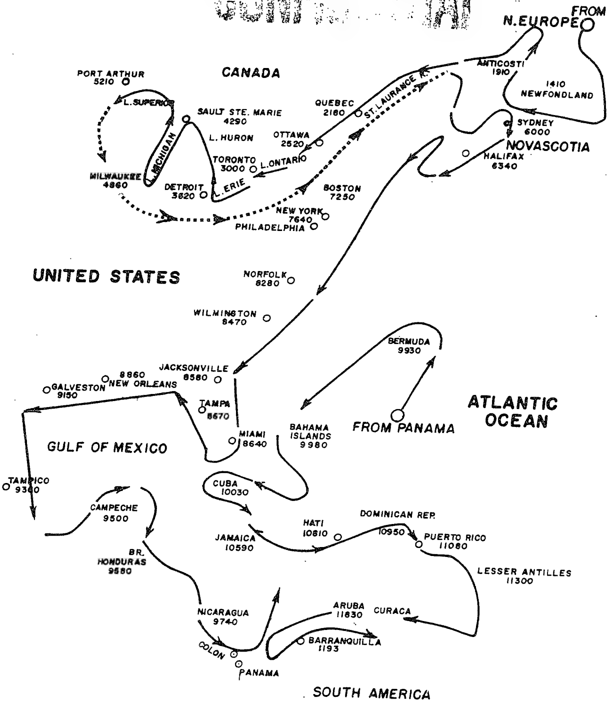
The method used was to select samples of ships with roughly similar exposures and then to determine whether, when, and where each ship was identified. Examination of the data showed that patrol aircraft surveillance was not fully mounted until October 24, the day the quarantine began. Accordingly, the samples were restricted to ships entering the surveillance area on or after October 25 and completing their transits through that before November 7.

It is not necessary to account for all ships which transited the area. It is sufficient to select a sample, if it is large enough, and without discrimination or bias. The samples are described below.

Sample 1: Ships listed in Lloyd's Shipping Index Voyage Supplement which made trips from Northern Europe to Caribbean and Gulf of Mexico ports. "Caribbean and Gulf Ports" include those shown in figure 12. "Northern Europe" includes French Atlantic ports, the British Isles, the low countries, Germany, Poland, Scandinavia, and Russian Baltic and White Sea ports, but not Spanish or Portuguese ports.

Sample 2: Voyages with the same origins and destinations as sample 1, but outbound from Gulf and Caribbean ports to Northern Europe.

Sample 3: Ships going from Southern European and Mediterranean ports to Caribbean and Gulf of Mexico ports.



Arrows show the geographic sequence, and numbers abreast selected ports indicate the numerical sequence of ports listed.

Gulf and Caribbean Ports Nos. 8640-11080 (Except 9930)

FIG. 12: GEOGRAPHIC SEQUENCE OF PORTS

Sample 4: Ships outbound from Caribbean and Gulf ports to Southern Europe and Mediterranean ports.

Samples 5 through 8 include ships on North-South and South-North runs.

Sample 5: Ships going south from the east coast of North America to Gulf of Mexico ports.

Sample 6: Northbound ships between the same sets of ports as in Sample 5.

Sample 7: Ships southbound from the east coast of North America to Caribbean Ports and the Panama Canal.

Sample 8: Northbound ships between the same ports as in Sample 7.

It was difficult in many cases to determine whether a ship identified and reported was the same as one of those on the sample lists because ship names were frequently misspelled or garbled. In particular, the Cyrillic letters of Russian ship names caused considerable difficulty.

A computer program was written to compare reported names with each other to be properly designated. Basically, this program associates two names if they differ by no more than two letter substitutions and/or letter transpositions. The program worked well to associate spellings such as Port Hudson and Fort Hudson. It did poorly on Cyrillic names: GYXAPECT is a garble of the Cyrillic БУХАРЕСТ , also reported correctly as BUCHAREST. The association of such names was not left to the computer.

There were also spellings such as BEADBACK for БЕЛОВОДСК (BELOVODSK), where the correct association was made only with luck. Some names reported were so distorted that it was not possible to identify the ship. Although a program might have been written to do the job, it would have been much more complicated than the one used, even though much of the task had to be done by human analysts.

The results are summarized in table XIV. The differences between inbound and outbound fractions identified, or east and westbound were not statistically significant at the 5 percent level.

A χ^2 test of the hypothesis that the probability of identification was the same for all 4 samples did not reject the hypothesis,even at the 10 percent level. Thus, aggregating samples is justified, yielding a common probability of .86 that a ship steaming between European or Mediterranean ports and the Caribbean Sea would be identified.

TABLE XIV

IDENTIFICATIONS OF SHIPS STEAMING BETWEEN EUROPE AND THE CARIBBEAN

	Sample						
	1	2	3	4	Westbound (1-4)	Eastbound (1-4)	Combined
Number of Ships	68	54	22	23	90	77	167
Identifications Number/Percent	57/84	51/94	17/77	19/83	74/82	70/91	144/86
Total Identifications by:*							
Ship Number/Percent	49/29	53/39	37/38	28/42	86/32	82/41	168/36
Landbased Aircraft Number/Percent	107/64	66/49	49/50	34/52	156/59	100/50	256/55
Carrier Aircraft Number/Percent	12/7	15/12	12/12	4/6	24/9	18/9	42/9
All Samples	168	134	98	66	266	200	466
Average Number of Identifications Per Ship by:							
Ship	.85	1.06	2.18	1.47	1.16	1.17	1.17
Landbased Aircraft	1.88	1.29	2.88	1.79	2.11	1.43	1.78
Carrier Aircraft	.21	.27	.71	.21	.32	.26	.29
All Sources	2.94	2.62	5.77	3.47	3.59	2.86	3.24

*Includes multiple identifications of same ship

The data of sample 3 shown in table XIV are distorted because 2 Russian ships, Grozny and Karl Marx, were repeatedly observed. Grozny was identified 17 times and Karl Marx 14 times because they were subject to special search and tracking, greatly increasing the frequency of sighting. These two have been omitted from figure 13, showing the frequency distribution of ship identifications.

These results indicate effective coverage of the ships going to and from the Caribbean and Gulf Ports or to Europe and the Mediterranean. The proportions identified are lower, rather than upper, estimates of effectiveness for the following reasons, considering that there is now rather complete knowledge of those ships in the area and available for identification. First, 586 ships were identified negatively. The high probability that a ship would be sighted and reported indicates that most, but not all, negatively identified vessels were probably also given a positive identification. Second, some of the identifications and sightings were either not reported or reported but not received for this analyis. Data were not received from 35 of 261 surveillance flights. Most of these were transits and would not be expected to produce many identifications, and many of the ships which these aircraft may have identified were also identified by other units. Nevertheless, any missing data could only increase the estimates of over-all effectiveness. Finally, some ships' names were transmitted with errors that now preclude identifying them.

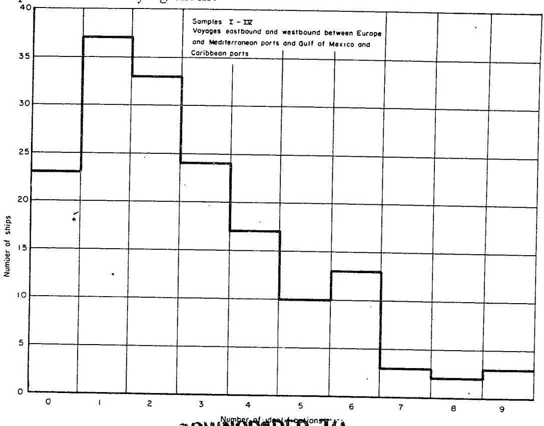


FIG. 13: FREQUENCY DISTRIBUTION OF IDENTIFICATIONS PER SHIP

The sampling data may also be used to indicate in more detail the relative contributions to surveillance of the several force components. Table XV and figure 13 consider samples 1 - 4. The identification results in the tables have been separated according to whether they were made on the eastern or western side of the barrier.

Table XV-A shows the distribution of first identifications. As planned, aircraft made over three-fourths of the first identifications on the westbound ships in the outer zone. Seventy-one percent of the westbound ships were first identified in the outer zone; 11 percent were first identified in the inner zone. Since the heaviest air coverage was east of the ship line, ships made a much higher proportion of the first contacts on the eastbound voyages. The distinction between zones is not particularly significant for eastbound ships.

Table XV-B shows the numbers of distinct identifications made by the forces in the 2 zones, indicating the percentages of transiting ships each component was able to identify by itself. Because of duplications and multiple identifications, the numbers and percentages of identifications do not add up to those identified by the combined effort. For example, considering the 90 westbound ships, land-based air identified 58 by the time they reached the quarantine line. Although landbased air also made 34 identifications west of the quarantine line, only 6 of these were new, giving landbased air a total of 64 ships identified, or 71 percent of the westbound traffic.

Table XV-C shows the "essential" contribution of each force component in each zone and in the entire surveillance area, that is, the incremental effect of each force component or the number of identifications by each component which would not otherwise have been made. For example, there were 6 westbound ships identified only by ships east of the quarantine line; 15 westbound ships were identified only by ships west of the line; and 8 westbound ships were identified only by ships during their transit through the entire surveillance area. Thus, without the contribution of the ships there would have been 8 more unidentified transits.

Although carrier air contributed substantially to surveillance, and identified about 20 percent of the transiting ships, their incremental effect was only 2 ships beyond those identified by land-based air and ships.

Table XVI compares the total contributions of component forces with their incremental contributions. Thus, landbased air identified a total of 64 of the westbound transitors; without that air effort 27 of the identified transitors would not have been identified, but the remaining 37 were also identified by either ship or carrier air.

TABLE XV-A

FIRST IDENTIFICATIONS OF SHIPS
European and Mediterranean to Gulf and Caribbean Ports

	Westbound		Eastbound		Combined	
	No.	%*	No.	%*	No.	%*
Total Voyages	90	100	77	100	167	100
First Identifications						
east of quarantine line						
by ships	3	11	2	3	10	7
by landbased air	50	68	17	24	67	46
by carrier air	6	8	2	3	8	6
Total	64	86	21	30	85	59
west of quarantine line						
by ships	5	7	39	56	44	30
by landbased air	3	4	10	14	13	9
by carrier air	2	3	0	0	2	1
Total	10	14	49	70	59	40
in total area						
by ships	13	18	41	59	54	37
by landbased air	53	72	27	38	80	55
by carrier air	8	11	2	3	10	100
Total	74	100	70	100	144	100

*Percentages are of all identified ships, not of the total number of ships.

TABLE XV-B

EAST AND WESTBOUND+SHIPS IDENTIFIED BY FORCE COMPONENTS

	Westbound		Eastbound		Combined	
	No.	%*	No.	%*	No.	%*
Total Voyages	90	100	77	100	167	100
Different Vessels Identified						
east of quarantine line						
by ships	22	24	5	6	27	16
by landbased air	58	64	39	51	97	58
by carrier air	15	17	15	20	30	18
by combined efforts	64	71	42	55	106	63
west of quarantine line						
by ships	31	34	44	57	75	45
by landbased air	34	38	33	43	67	40
by carrier air	2	2	1	1	3	2
by combined efforts	50	56	49	64	99	59
in total area						
by ships	43	48	46	60	89	53
by landbased air	64	71	59	77	123	74
by carrier air	17	19	16	21	33	20
by combined efforts	74	82	70	91	144	86

+Includes duplications and multiple identifications
*Percentages are [illegible] ships

TABLE XV-C

NUMBERS OF IDENTIFICATIONS MADE BY ONE FORCE COMPONENT ONLY

	Westbound		Eastbound		Combined	
	No.	% *	No.	% *	No.	% *
Number of Identifications	74	100	70	100	144	100
Identifications Unique to One Component						
east of quarantine line						
by ships	6	8	1	1	7	5
by landbased air	34	46	26	37	60	41
by carrier air	0	0	3	4	3	2
west of quarantine line						
by ships	15	20	17	24	32	22
by landbased air	17	23	6	8	23	16
by carrier air	0	0	0	0	0	0
Total						
by ships	8	11	9	13	17	12
by landbased air	27	36	19	27	46	32
by carrier air	0	0	2	3	2	1

*Percentages in this table are percentages of the total number of identifications.

TABLE XVI

TOTAL AND MARGINAL CONTRIBUTIONS TO THE SURVEILLANCE RESULTS FOR 90 WESTBOUND TRANSITS

	Total Identifications		Marginal Contribution	
	No.	% of Identified Ships	No.	% of Identified Ships
Ships	43	58	8	11
Landbased Air	64	86	27	36
Carrier Air	17	23	0	0
Combined Forces	74	100		

A smaller fraction of ships on north-south runs was detected than on east-west voyages, as shown in table XVII, because the surveillance width in the north-south direction was about 1300 miles, compared to 2000 miles east and west. More important, however, was the disposition of forces, particularly ships, in a manner to intercept ships between Europe and Cuba. Finally, much of the flying was east of the track between North American east coast ports and the Gulf-Caribbean area.

Not only was there a lower percentage of ships identified while transiting north-south or south-north, but there were also fewer repeat identifications. As a result, there were more instances of identification by only one component (62 percent of the ships identified, compared to 45 percent for eastbound and westbound transits). Again, the marginal contribution of carrier air was small, due to their deployment.

TABLE XVII

NUMBERS OF TRANSITING VESSELS IDENTIFIED ON NORTHBOUND AND SOUTHBOUNDTRANSITS THROUGH THE SURVEILLANCE AREA

	Southbound		Northbound		Combined	
	No.	%	No.	%	No.	%
Total Voyages	246	100	168	100	414	100
Identified	190	77	109	65	299	72
First Identifications by:*						
Ship	68	36	60	55	128	43
Landbased Air	104	55	45	41	149	50
Carrier Air	18	9	4	4	22	7
Different Vessels Identified by:**						
Ship	106	43	68	40	174	42
Landbased Air	126	51	82	49	208	50
Carrier Air	23	9	12	7	35	8
Vessels Identified Only by:*						
Ship	51	27	27	25	78	26
Landbased Air	68	36	29	27	97	32
Carrier Air	10	5	2	2	12	4

* Percentages shown are percentages of identifications.

** Percentages shown are percentages of voyages.

VII. IMPROVEMENT OF FUTURE ANALYSES

Future analyses of this type could be improved by insuring better and more complete data. The Cubex data were not transcribed until 4 months after the operation, and many of those responsible for transcribing it had had little to do with the aspects of the operation under study. Consequently, when information was missing or obviously wrong, little could be done to supply or correct it.

The quality of data can be much improved if the analysis team is present during the operation and can examine the data being generated. Preferably, an analysis team should be organized in advance and become ready to report promptly in a significant operation. Such a team could be named or mentioned in appropriate OpPlans and check-off lists. At the very least, an earlier decision should be made on the scope and nature of analyses. In analyses of this type, the nature of the operation is unlikely to be precisely known in advance and it is not possible to anticipate all the reporting needs for analysis. It is impossible to report routinely all data required by every conceivable contingency. Hence, many reports are to be filled out only in specific circumstances. Such reports will contain some discrepancies when filled out the first few times. Thus, it is desirable that basic information, essential in most analyses, be reported routinely and that special reporting requirements be minimized and simplified.

The various reporting forms contain considerable redundancy. There is a basic body of information needed for nearly all reports and analyses, pieces of which may be available at different places and to different people. This makes it difficult or impossible to assemble information without some redundancy, and information from original forms must be transcribed to one coherent form. For example, ship's course, speed, and position is normally logged on the bridge. Information about an ECM contact is logged in CIC. Both sets of information may be available in both places, but the information is recorded separately.

Much information now being recorded could be entered on a form which permits easy conversion for machine analysis. As an example, consider a ship's quartermaster's log. It may contain courses or headings, speeds, positions, times, and changes in these. All of these could be recorded on a standard form with a special marking pencil, so that the completed forms could be handled automatically without further transcription. Thus, it would be possible to enter the history of a ship's movements into a computer, eliminating much clerical labor and the possiblity of transcription or coding errors. Narrative information would still be required and could be entered beside or between sections of numerical data. It appears possible to standardize this type of record considerably for machine use and at the same time reduce, or at least not increase, routine record-keeping.

References: (a) Commander Antisubmarine Warfare Force, U.S. Atlantic Fleet ser 00187/43 of 5 Nov 1963 to Chief of Naval Operations w/encl. Summary, Analysis and Evaluation of Cubex Secret

(b) CinCLant ser 000119, "CinCLantHistorical Account of Cuban Crisis" Top Secret 29 Apr 1963

(c) Operations Evaluation Group, Center for Naval Analyses, Study 679, Analysis of the Cuban Quarantine; Commander Second Fleet Communication During the Initial Phase (U), Confidential 1 Jul 1964

(d) Memo for DCNO from ACNO (Plans and Policy) Ser 001569P60 17 Dec 1962 "Ocean Surveillance, Search and Tracking; study of (U)" Secret

(e) Memo for Distribution Ser 0058P36 from Op-03C "Ocean Surveillance, Search and Tracking; first meeting for study of (U)" Secret 31 Dec 1962

(f) Memo to Dir, OEG from Op-354 Ser #1-63 2 Jan 1963 "Force Utilization in Cuban Quarantine Operation; analysis of" (work request)

(g) ComASWForLant MSG 262249Z Oct 62 "OP Order 15-62" Confidential

(h) Institute of Naval Studies, Center for Naval Analyses, "Report of Ocean Surveillance Study" Secret Apr 1963

APPENDIX A

APPENDIX A

EFFECT OF MORE SYSTEMATIC SURVEILLANCE UPON THE OVER-ALL EFFECTIVENESS OF THE QUARANTINE

The use of ships and aircraft on special searches for the tracking of a designated ship reduced the number of ships and aircraft available for systematic coverage or barrier type operations. The aircraft on special search and track missions averaged less than 2 identifications per flight, while the aircraft on surveillance missions averaged 7. Moreover, identifications made by aircraft on special missions were likely to be duplicated by other units on routine surveillance missions. If the effort devoted to special search and tracking had been used as part of the systematic search, how much better would the identification performance have been?

According to table XV-B, landbased aircraft identified 74 percent of a sample of 167 vessels travelling westward or eastward in the surveillance area, while ships identified 53 percent. If it can be assumed that ship and aircraft identifications were independent, the expected percentage of transiters identified by the combined efforts of ships and landbased air is 1 - (1-.74) (1-.53) = .88. This agrees well with the actual result of 86 percent of the sample identified.

If we assume that the patrol aircraft on the 36 special search and track missions before Nov. 8 might have achieved results on pure surveillance flight comparable to the average, then they might have made 36 x 7 = 252 identifications instead of the 57 reported. This might have led to an increase in the total of 2085 identifications made by patrol aircraft by 195, or slightly over 9 percent. Furthermore, if all 252 identifications were new, the resulting increase would be 12 percent.

Since the number of destroyer and cruiser ship-days devoted to special search and tracking was also about 10 percent of that devoted to ocean surveillance, it is convenient to consider the potential effect of increasing by 10 percent the percentage of identifications achieved by each component. The combined effects on independent identifications might then lead to a percentage of ships identified of 1 - (1-.81) (1-.58) = .92.

The situation with respect to the aircraft carriers is not clear. The data forms showing primary mission of the ship reported 14 days on ocean surveillance and 10 days on special search and track. However, the aircraft carrier's reports of missions showed very little time on special search and track. The results on over-all effectiveness in the main body of this report show that carrier aircraft to a large extent duplicated identifications by the patrol aircraft and ships. If this redundancy were avoided by using the carriers to cover one portion of a barrier line, greater efficiency might have been obtained. However, this would have removed carrier air from other missions, such as ASW and air support, which they were to perform. Therefore, only the effects of additional contributions from ships and patrol aircraft have been considered here.

Thus, a 10 percent increase in the effectiveness of individual forces would be expected to result in a less than proportional (5 percent) increase in the over-all effectiveness, mainly because the coverage was already near saturation.

APPENDIX B

APPENDIX B

COMPARISON OF FORCE REQUIREMENTS ON AIR BARRIERS DESIGNED FOR ONE-WAY AND TWO-WAY SHIP TRAFFIC

For a racetrack barrier designed to intercept two-way traffic across a line of length L, flights must make roundtrips from A to B and back every $\frac{2W}{V_s}$ hours, where W is the width of detection on each side of the aircraft and V_s is the speed of a transiting ship. The length of each flight is 2 L miles and it takes 2 L/V_a hours, where V_a is aircraft speed. Hence $24 \div \frac{2W}{V_s}$ flights take off each day and the flying hours per day are $H = 24 \ \frac{V_s}{V_a} \cdot \frac{L}{W}$.

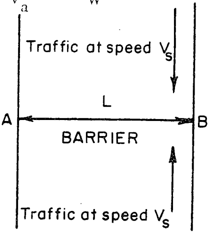


FIG. B-1: RACETRACK BARRIER TO INTERCEPT TWO-WAY TRAFFIC

Sample calculation for a two-way barrier:

$$L = 600$$
$$V_a = 150$$
$$V_s = 15$$
$$W = 45$$

$$H = 24 \ \frac{V_s}{V_a} \quad \frac{L}{W} = 24 \left(\frac{15}{150}\right) \cdot \left(\frac{600}{45}\right) = 32 \text{ flying hours daily.}$$

In a symmetric crossover barrier, designed for intercept of traffic in only one direction, the flights take the path A" A' B' B" A" A. The legs A' B' and B" A" take $L/\sqrt{V_a^2 - V_s^2}$ hours each and the other 2 legs take $\frac{2W}{V_a+V_s}$ hours each. The required daily number of flights is $24 \div \frac{4W}{V_s} = \frac{6V_s}{W}$. Hence daily flying hours are

$$H = \frac{12V_s}{\sqrt{V_a^2 - V_s^2}} \cdot \frac{L}{W} + \frac{24\ V_s}{V_a+V_s} .$$

Sample calculation for a crossover, one-way barrier:

$$L = 600$$
$$V_a = 150$$
$$V_s = 15$$
$$W = 45$$

$$H = \frac{12 \cdot 15}{\sqrt{22{,}500 - 225}} \cdot \frac{600}{45} + 24\left(\frac{15}{165}\right)$$

$$= \frac{12}{\sqrt{99}} \cdot \frac{40}{3} + \frac{24}{11}$$

= 18 flying hours daily.

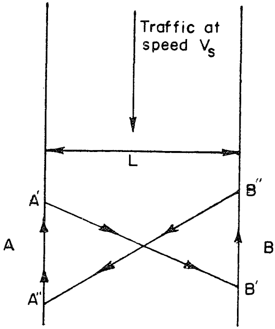


FIG. B-2: CROSSOVER BARRIER TO INTERCEPT TRAFFIC FROM ONE DIRECTION

APPENDIX C

APPENDIX C

ESTIMATING IDENTIFICATION WIDTHS FOR PATROL AIRCRAFT

Suppose an aircraft patrols along a track of length L through a large area in which ships are randomly distributed with an average density of s ships per unit area. Let $P(x)$ be the probability that a ship at a distance of x miles perpendicular to the aircraft track will be identified and let

$$W = \int_{-\infty}^{\infty} P(x)\, dx$$

be the identification width. In a strip of width Δx parallel to the track at distance x, the expected number of targets identified will be $L \cdot s \cdot \Delta x \cdot P(x)$, and the distribution will be Poisson. Since the sum of random variables with Poisson distributions is a random variable with Poisson distribution, where the combined mean is the sum of the individual means, then the expected number of ships identified at all ranges from the aircraft's track will be WLs.

In Cubex, aircraft flew predetermined tracks with instructions to identify shipping within a range of $\frac{R}{2}$ = 45 miles on either side of their tracks (30 miles from 21-24 October). The area swept was therefore LR, with an expected number of contacts C = LRs. This number of contacts may be considered as a random variable with a Poisson distribution having a mean C = WLs and standard deviation $\sqrt{C} = \sqrt{WLs}$.

To estimate identification width in Cubex, data are available for $5^\circ \times 5^\circ$ regions, including for each region its area (A_i), the average number of ships present (S_i) surveillance track length (L_i), and the number of identified contacts (C_i). Letting $s_i' = \frac{S_i}{A_i}$, C_i is assumed to be a random variable with Poisson distribution whose mean is WL_is_i, where W is the (unknown) identification sweep width. Since L_i and s_i are constants, $W_i = \frac{C_i}{L_i s_i}$ is a random variable whose expected value is W and whose variance is $\frac{W}{L_i s_i}$. Thus for each $5^\circ \times 5^\circ$ region we obtain a separate estimate of W.

Assuming that the hypothetical value of W is constant over the entire surveillance area, the estimates for any two regions, $W_1 = \frac{C_1}{L_1 s_1}$ and $W_2 = \frac{C_2}{L_2 s_2}$, have the same expected value (W) and variances $\frac{W}{L_1 s_1}$ and $\frac{W}{L_2 s_2}$. A linear combination of 2 independent values of W_i,

$$W_{1,2} = a_1 W_1 + a_2 W_2 \ .$$

will have an expected (mean) value of $(a_1 + a_2)$ W and a variance

$$V_{1,2} = \left(\frac{a_1^2}{L_1 s_1} + \frac{a_2^2}{L_2 s_2} \right) W \ .$$

In particular, $W_{1,2}$ will be an unbiased estimate of W if $a_1 + a_2 = 1$.

In order to select suitable values for the coefficients a_1 and a_2, it is desirable to minimize the variance. By differentiating $V_{1,2}$ with respect to a_1, it can readily be shown that

$$\widetilde{W}_{1,2} = \frac{L_1 s_1 W_1}{L_1 s_1 + L_2 s_2} + \frac{L_2 s_2 W_2}{L_1 s_1 + L_2 s_2}$$

$$= \frac{C_1 + C_2}{L_1 s_1 + L_2 s_2}$$

is the desired estimate. By the same reasoning, an over-all best estimate for n regions can be shown to be

$$W^* = \frac{\sum_{i=1}^{n} C_i}{\sum_{i=1}^{n} L_i s_i}$$

with a mean of W and a (minimum) variance

$$V^* = \frac{\sum_{i=1}^{n} C_i}{\prod_{i=1}^{n} L_i s_i} \ .$$

It may be observed that when $a_1 = -a_2 = 1$, $W_{1,2} = W_1 - W_2$ has a mean of 0 and a variance $\left(\frac{1}{L_1 s_1} + \frac{1}{L_2 s_2}\right) W$. Since the observed numbers of identified contacts in Cubex, C_i, are large, the Poisson distribution may be approximated by a normal distribution in order to test for significant differences between pairs of values of W_i. Specifically,

$$x = \frac{(W_1 - W_2)\,[(L_1 s_1)(L_2 s_2)]^{1/2}}{[L_1 s_1 W_1 + L_2 s_2 W_2]^{1/2}} = \frac{(W_1 - W_2)(L_1 s_1)^{1/2}(L_2 s_2)^{1/2}}{(C_1 + C_2)^{1/2}}$$

may be considered as a normally distributed variable with mean 0 and variance 1 to test the hypothesis of no significant difference between W_1 and W_2 at any specified level of statistical confidence.

NONE

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13. ABSTRACT

In late 1962 Navy ships and aircraft intensively patrolled large Atlantic and Caribbean areas to locate and track Soviet Bloc ships suspected of carrying intermediate range missiles and support equipment to Cuba. This study analyzes the effectiveness of these quarantine operations and the contributions of the several naval components. Because of the special circumstances of the Cuban crisis, the operations were carried on under conditions which greatly increased the force requirements.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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Sea surveillance						
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